

Privy Council

MEDICAL RESEARCH COUNCIL

The Effects of Alcohol and some other
Drugs during Normal and Fatigued
Conditions



UNIVERSITY
COLLEGE,
LONDON.

LONDON

PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

1920

Price 1s. net.



22500166780

Privy Council

S.B. and I — **MEDICAL RESEARCH
COUNCIL**

**The Effects of Alcohol and some other
Drugs during Normal and Fatigued
Conditions**



**UNIVERSITY
COLLEGE
LONDON**

LONDON

PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE

1920

14805591

Medical Research Council.

The VISCOUNT GOSCHEN, C.B.E. (*Chairman*).

WILLIAM GRAHAM, M.P.

The Hon. EDWARD F. L. WOOD, M.P. (*Treasurer*).

C. J. BOND, C.M.G., F.R.C.S.

Professor WILLIAM BULLOCH, M.D., LL.D., F.R.S.

T. R. ELLIOTT, C.B.E., D.S.O., M.D., F.R.S.

HENRY HEAD, M.D., F.R.S.

Professor F. G. HOPKINS, D.Sc., F.R.C.P., F.R.S.

Major-General SIR WILLIAM LEISHMAN, K.C.M.G., C.B., F.R.S.

Professor NOEL PATON, M.D., F.R.S.

SIR WALTER M. FLETCHER, K.B.E., M.D., F.R.S. (*Secretary*).

15, BUCKINGHAM STREET,

STRAND, W.C. 2.

WELLCOME INSTITUTE LIBRARY	
Coll.	welMomec
Call	pam
No.	QV82
	1920
	M13e

27045

INTRODUCTION

THE present report is the third of a series of memoirs published by the Medical Research Council at the request of the Central Control Board (Liquor Traffic). The earlier of the experiments now described were part of an investigation independently undertaken before the beginning of the war, but the later ones were devised to answer problems suggested to the authors by the Chairman of the Board.

In some respects the value of the experiments is enhanced, in other respects it is restricted by their at once extensive and limited character. They are extensive in so far as they deal with certain mental effects not only of alcohol, but of opium, strychnine, tea, chloroform, &c. But any loss of intensiveness arising from experiments over so wide a pharmacological field receives compensation from the similar and opposite actions revealed by their comparison. These drugs appear to fall into two antagonistic groups, (i) alcohol and chloroform, and (ii) strychnine, opium, and tea, in regard to the tests applied.

On the other hand, these experiments are limited in scope since they were carried out by only two subjects, the greater number indeed being performed on only one subject, who had never to her knowledge previously taken alcohol in any form. But although caution must be exercised in generalizing from conclusions thus based, they acquire more than ordinary value inasmuch as they issue from two experts well trained to avoid the inevitable pitfalls of human experiment. Thus they have followed Dr. Rivers's example of disguising the drugs taken and of employing control mixtures, indistinguishable from the disguised drugs and taken on the days when the latter were not taken, so that suggestion arising from foreknowledge could play no part in obscuring the true effect of the drug.

The writers' researches on the mental effects of alcohol will naturally receive principal attention. They find that, despite the subjective feelings of greater ease in carrying out the tests, alcohol produces in them a distinct loss of precision in the dotting test, a well-marked loss of power of recall in the memory tests, and a striking reduction in the rate of alternation of phases in the 'windmill' illusion. The last-named, indeed, is claimed as a very delicate index of drug effects, the writers ascribing the reduced rate of phase alternations to a rise in the resistance offered by the synapses of the neurons to the passage of the nervous impulse. Opium acts in a directly opposite manner. It accelerates the rate of phase alternations in the 'windmill' illusion, while it diminishes

the errors in the dotting and in the memory tests, the attention being more easily directed to the task and to the meaning of the words learnt, and the process of recall being likewise facilitated.

Applying the dotting and other tests to ascertain the influence of food taken with alcohol, the writers find little subjective or objective effects when alcohol, to an amount of 30 c.c., is taken with a meal, whereas when it is taken from two to five hours after a meal the effects are unquestionable in the tests employed. Applying the dotting test to determine the effects of the degree of dilution of alcohol, they conclude that the weaker the solution the less marked are its effects. Both these results are in agreement with those of Dr. Mellanby (Report No. 31 of this series) and of Dr. Vernon (Report No. 34), but they call for further research.

A more extended investigation is also necessary in the light of the authors' interesting discovery that in the course of the protracted fatigue effects following several nights' loss of sleep, alcohol acts deleteriously during the stages of increasing inefficiency, whereas it acts beneficially as the subject later begins to regain his previous efficiency. At the former stage it increases the errors, at the latter it reduces the errors made in the tests. This suggests that an important cause of the conflicting results of past workers may be due to the stage or degree of fatigue when alcohol was taken.

MEDICAL RESEARCH COUNCIL,
15 BUCKINGHAM STREET,
STRAND, LONDON, W.C.2.

September 1, 1920.

THE EFFECTS OF ALCOHOL AND SOME OTHER DRUGS DURING NORMAL AND FATIGUED CONDITIONS.

By WILLIAM McDougall, F.R.S. and MAY SMITH, M.A. (*from the
Psychological Laboratory, Oxford*).

CONTENTS

	PAGE
I. GENERAL INTRODUCTION	6
II. THE 'DOTTING MACHINE' AS A MEANS OF MEASURING THE EFFECTS OF ALCOHOL, OPIUM, AND STRYCHNINE	7
(a) Alcohol during Normal Conditions	10
(b) Alcohol during the Fatigued State resulting from Loss of Sleep	13
(c) The Effect of Time Intervals and Control Mixtures	14
(d) Opium during Normal Conditions	15
(e) Opium during Fatigue	16
(f) The Curve of Recovery after Opium	17
(g) Strychnine	17
III. 'MEMORY FOR RELATED WORDS' AS A MEANS OF MEASURING THE EFFECTS OF ALCOHOL, OPIUM, AND STRYCHNINE	18
(a) Alcohol during Normal Conditions	19
(b) Alcohol during Fatigue	19
(c) Opium	21
(d) Strychnine	21
IV. COMBINATION OF THE 'DOTTING MACHINE' AND 'MEMORY FOR RELATED WORDS' AS A MEASURE OF THE EFFECTS OF ALCOHOL AND OPIUM	22
(a) Alcohol	22
(b) Opium	22
V. THE 'PERCEPTION OF AMBIGUOUS FIGURES' AS AFFECTED BY ALCOHOL AND OTHER DRUGS, TEA, AND FATIGUE	24
(a) Alcohol	25
(b) Chloroform	26
(c) Strychnine	27
(d) Tea	28
(e) Opium	28
(f) Potassium Bromide	28
(g) Fatigue	29
Summary	29
VI. SUBJECTIVE EFFECTS OF THE DRUGS	30
(a) Alcohol	30
(b) Opium	30
VII. SOME PRACTICAL APPLICATIONS TO THE STUDY OF ALCOHOL	31
(a) The Effect of the Degree of Dilution	31
(b) The Effect of a preceding Meal	32
VIII. GENERAL SUMMARY	34

I. GENERAL INTRODUCTION.

THE effects of alcohol, as expressed in terms of physiological or mental change, have been the subject of many experiments,¹ while in the public press and elsewhere medical men and others have defended diametrically opposite views as to its action, views apparently equally supported by facts.

The present investigation was undertaken primarily with the object of:

(1) Finding tests which would measure objectively the effects of drugs.

(2) Measuring the effects of moderate doses of alcohol and other drugs on the normal state; by the normal state is understood the general physiological conditions resulting at a given time of day from one's customary work.

(3) Determining the effect of the same quantities of alcohol and other drugs on the state supervening on considerable loss of sleep.

The following control precautions were taken:

(1) Daily records for many weeks were obtained, so that a comparison could be made between the drug effect, if any, and (a) the record for the day, (b) the weekly average.

(2) In order to ensure that the differences, if present, were due to the drug and not merely to the interval elapsing between two sets of experiments, the effects of time intervals, viz. 30 minutes, 60 minutes, were obtained for a period of about 12 months.

(3) The drugs forming the subject of the inquiry were all disguised² by one of us, so that one subject was in ignorance both as to their nature and number in the case of all the experiments dated 1913, 1914. Except where there is a statement to the contrary the writers were the subjects of the experiments.

(4) Mixtures containing no drugs, but resembling the drug mixtures in taste and appearance, were taken at irregular intervals, and so formed a control group.

(5) In the case of those mixtures which had marked physiological and subjective effects, one subject had no means of knowing that several might not have like effects.

(6) Prior to the investigation one subject had never to her knowledge taken alcohol in any form.

(7) The same time of day, viz. between 2 p.m. and 7 p.m., was as far as possible reserved for all the experiments. The usual method was to obtain a record of the particular test before taking the drug, then to take the drug, and after an interval obtain other records.

After about one hundred experiments with mixtures containing either caffeine, potassium bromide, ethyl alcohol, tincture of opium, strychnine, or the control mixture, it was found that the first two

¹ Cf. RIVERS, *Influence of Alcohol and other Drugs on Fatigue*; London, 1907; DODGE and BENEDICT, *Psychological Effects of Alcohol*, 1915.

² The disguise was usually effected by mixing small quantities of quinine, oil of peppermint, and coffee with the solution to be taken.

had no measurable effect on the subjects, while the alcohol and opium had such consistently marked effects, both subjectively and objectively, that future experiments in the case of one of us were chiefly concerned with a more detailed investigation of these two, and a few experiments with strychnine.

II. THE 'DOTTING MACHINE' AS A MEANS OF MEASURING THE EFFECTS OF ALCOHOL, OPIUM, AND STRYCHNINE.

The method was devised by one of us (McD.) as a test of sustained voluntary attention as long ago as the year 1900. The apparatus used in our experiments was the much improved form made by the Cambridge Scientific Instrument Co. at the suggestion of Dr. Rivers. It is essentially a 'mechanical device whereby a continuous band of paper tape, about one inch wide, is drawn behind an opening, or window, in the top of the desk, by a weight-driven clockwork movement'. Along the width of the band small red circles are distributed in as irregular a manner as possible, but at equal intervals. The test consists in marking the red circles with a stylographic pen as they pass before the subject's field of vision.¹ For these experiments a length of tape six metres long was the standard. This consisted of 1,200 small red circles, and the machine was so adjusted that the circles passed before the field of vision at a uniform rate of 5.8 a second. In each metre fifteen circles at irregular intervals were coloured blue beforehand, and these, when they appeared, were not to be dotted, but instead, the right hand had to be lifted to avoid marking the circle, while with the left hand a key had to be tapped, which, being attached to a pen arrangement under the lid of the machine, marked the tape and thus showed if the key had been tapped. It was possible to get by this means a very fine test of one's power of inhibition.²

Errors were of four types:—

- (a) A circle allowed to pass unmarked.
- (b) A blue circle marked which ought to have been left unmarked.
- (c) An extra dot inserted between two circles.
- (d) Slight deviations in either a lateral or vertical direction from the circle aimed at.

In estimating the errors, *a*, *b*, and *c* counted as one error on each occasion, *d* counted as half an error, if less than 2 mm.

(a) *Alcohol during Normal Conditions.*

There are in all thirty-three records of the effect of alcohol on the ordinary normal state; by which is meant a state in which there was no fatigue except such as might be assumed to be present normally at such a time of day.

¹ BURT, 'Experimental Tests of General Intelligence,' *Brit. J. Psychol.*, 1909, 3, 153; SMITH, 'A Contribution to the Study of Fatigue,' *Brit. J. Psychol.*, 1916, 8, 329.

² With subjects less practised than the writer at this particular test it is quite sufficient to have each circle marked simply without the complications described above. The subject (M. S.) of these experiments had been using this test as a fatigue test for several years.

The doses varied from 10 c.c. to 30 c.c. of absolute alcohol (mixed with three parts of water), but most of the experiments were done with doses of 15 c.c. or 20 c.c. The time of day given in the table is the time when the drug was taken.

With 10 c.c. there are ten experiments, the details of which are given below.

No.	Date.	Drug taken at	No. of Errors immediately before taking Alcohol.	No. of Errors one hour ¹ after taking Alcohol.
1.	24 June, 1913	5.15 p.m.	79	115
2.	3 July, 1913	5.30 p.m.	81	63
3.	13 July, 1913	5.45 p.m.	84	113
4.	20 July, 1913	6.30 p.m.	76	106
5.	25 July, 1913	5 p.m.	83	84
6.	27 July, 1913	6.10 p.m.	79	111
7.	22 Nov., 1913	5 p.m.	71	89
8.	28 Nov., 1913	4.30 p.m.	80	102
9.	3 Dec., 1913	5.20 p.m.	89	83
10.	31 March, 1914	4.50 p.m.	82	107
			Mean: 80.4	Mean: 97.3

21 per cent. increase in the number of errors.

It will be noticed that in eight cases, there is an increase in the number of errors after taking the drug, although in one case so slight as to fall within normal variation.

In the two remaining cases, viz. 2 and 9, alcohol is followed by a decrease in the number of errors, in one case so small as to fall within normal variation, in the other case a normal of 81 is followed by 63, a result better than normal. The subjective comment made before performing this experiment is 'very tired'; in the later experiments, showing the effect of alcohol on a fatigued state, we may get some explanation.

There are eleven experiments with 15 c.c. alcohol, and of these in ten cases there is an increase in the number of errors, though in some cases a very slight one.

No.	Date.	Drug taken at	No. of Errors immediately before taking Alcohol.	No. of Errors one hour after taking Alcohol.
1.	28 June, 1913	5 p.m.	54	77
2.	6 July, 1913	6.10 p.m.	80	177
3.	17 July, 1913	5.15 p.m.	85	189
4.	22 July, 1913	4.35 p.m.	76	97
5.	23 Nov., 1913	6 p.m.	93	123
6.	6 Dec., 1913	6 p.m.	68	112
7.	12 Dec., 1913	4.10 p.m.	78	54
8.	21 Feb., 1914	5.10 p.m.	102	106
9.	3 March, 1914	3.15 p.m.	87	109
10.	29 May, 1914	4.15 p.m.	57	77
11.	2 June, 1914	3.30 p.m.	73	76
			Mean: 77.5	Mean: 109.2

42 per cent. increase in number of errors.

In one case, No. 7, there is improvement after alcohol, viz. only 54 errors.

¹ The original time interval of one hour was chosen for practical purposes as these experiments had to be arranged during leisure time. Later an attempt was made to adjust the claims of our other work to these experiments, but such was not always possible.

With 20 c.c. there are nine experiments, eight of which are followed by an increased number of errors after alcohol, No. 6 being the exception.

No.	Date.	Drug taken at	No. of Errors immediately before taking Alcohol.	No. of Errors one hour after taking Alcohol.
1.	18 June, 1913	5.5 p.m.	61	114
2.	1 Dec., 1913	3 p.m.	87	100
3.	7 Dec., 1913	6 p.m.	72	154
4.	10 Dec., 1913	3.10 p.m.	53	57
5.	16 Dec., 1913	11.10 a.m.	50	63
6.	18 Dec., 1913	4.45 p.m.	63	54
7.	7 Feb., 1914	6.25 p.m.	41	69
8.	13 Feb., 1914	4.20 p.m.	110	117
9.	15 May, 1915	6 p.m.	93	147
			Mean : 70.0	Mean : 97.2

39 per cent. increase in the number of errors.

It will be noticed that with this dosage in one case, No. 6, there is a decrease in the number of errors after the drug, whereas in the other cases there is a considerable increase except in No. 4 and No. 8, which would fall within normal variation.

With 25 c.c. only three experiments were made, and in each case there is an increase in the number of errors made after taking alcohol.

No.	Date.	Drug taken at	No. of Errors immediately before taking Alcohol.	No. of Errors one hour after taking Alcohol.
1.	8 Dec., 1913	4.50 p.m.	75	122
2.	27 Feb., 1914	3.50 p.m.	75	148
3.	23 May, 1914	2.20 p.m.	81	223
			Mean : 77	Mean : 164

113 per cent. increase in the number of errors.

It has been mentioned above that it is possible to have several types of error. In the tables all types are pooled as the effect of the alcohol is shown by a proportional increase of all types, i. e. in extra dots inserted between the circles as well as in ineffective shots falling short of the circle.

After such doses as are represented in these experiments, alcohol seems in the majority of cases to be followed by a marked loss of accuracy and of control, the latter being illustrated by the increase in the number of insertions.

A quite common subjective effect, which accompanied many of the alcohol experiments was a pleasant conviction that the dotting was very good; in fact that particular view persisted long after the delusive nature of the experience was well known, and it frequently crossed the subject's mind that in this or that particular case alcohol was not having its usual effect, only to find the customary increase in the errors when they were counted. It will have been noticed that in several cases in the above experiments alcohol was followed by a slight improvement. Perhaps some light will be thrown on these when the influence of alcohol on a fatigued state is considered.

(b) *Alcohol during the Fatigued State resulting from Loss of Sleep.*¹

The effect of alcohol during the fatigued state was incidental to an investigation on fatigue which had for one of its aims to trace the nature of the recovery curve after the fatigue ensuing from a voluntary cutting down of the normal amount of sleep for three nights.² The effect of loss of sleep, as tested by the dotting machine, showed itself in two distinct phases:

(1) A phase of about three days' duration when fatigue acted apparently as a stimulant, so that the errors were fewer than in the normal state.

(2) A phase of longer duration, about thirteen days, when the errors gradually rose to a number considerably higher than normal, followed by a somewhat irregular return to the normal.

The effects of alcohol were observed in the course of four 'fatigue cycles'.³ To avoid the possibility of the subject becoming accustomed to a certain amount of the drug, no attempt was made to get daily records, and in fact during the first of these four cycles only six days out of the 23 during which fatigue conditions prevailed, were alcohol days; on the other days either other drugs or a mixture disguised as a drug had been taken.

In the last of the four the investigation was confined to the effects of alcohol, and as it contains more experiments than the previous ones it has been given in detail. On this occasion the subject knew that alcohol was being taken, but this knowledge did not give results in conflict with the earlier ones done in ignorance of the drug.

The dosage was on each occasion 15 c.c., and the experiments began at 2.30 p.m. each day. As a result of one night with only one and a half hours' sleep, the errors in the dotting fell from an average of 52 for the preceding fortnight to 38; half an hour after having taken 15 c.c. alcohol the errors rose to 137, a number greater than any resulting from fatigue during this 'cycle'.

Three days later alcohol records were again obtained and the errors increased from 45 before to 113 after alcohol. Daily records were obtained in order to trace the fatigue curve, but alcohol records only on a few days.

Four days later, by which time the second fatigue phase was in evidence, as shown by the rise of the errors to 109, alcohol increased this number to 161, and for several days there were similar records (see Graph I).

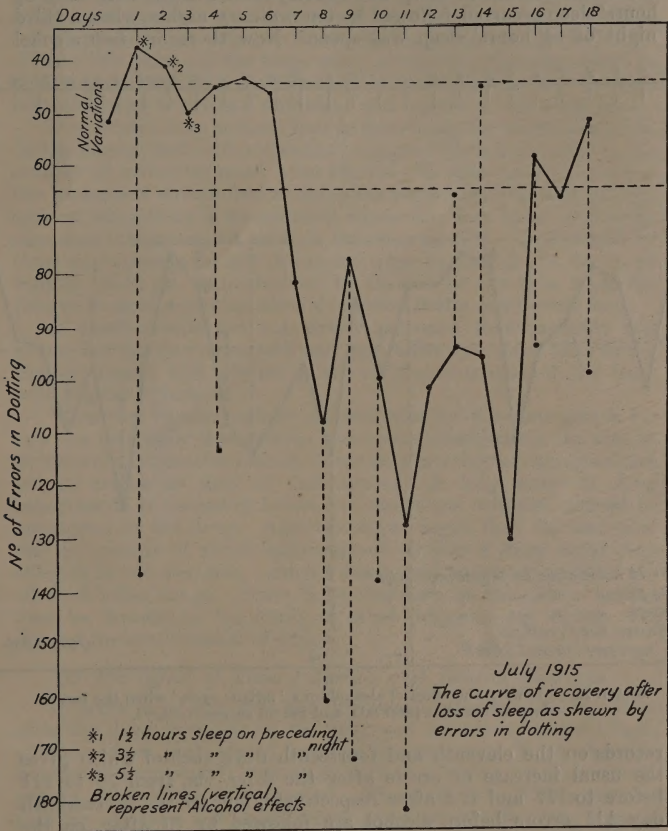
Towards the end of the fatigue cycle, however, when the graph shows a tendency to approach the normal, the alcohol reaction is different; for on the thirteenth day the errors in dotting being 95, the effect of alcohol is to reduce the errors in dotting to 66, with a similar result on the following day, viz. 96 errors in

¹ Throughout this paper the word 'fatigue' is used for the effect of loss of sleep. In order to keep awake for the pre-arranged number of hours the subject (M. S.) worked to a time-table, drawn up beforehand, and the work done was as near as possible to that of the usual daily routine.

² For full details of the fatigue experiments see *Brit. J. Psychol.*, 1916, 8, 327.

³ By 'fatigue cycle' is meant the period covered by the actual loss of sleep and the return to a normal. The whole generally occupied from 16 to 25 days.

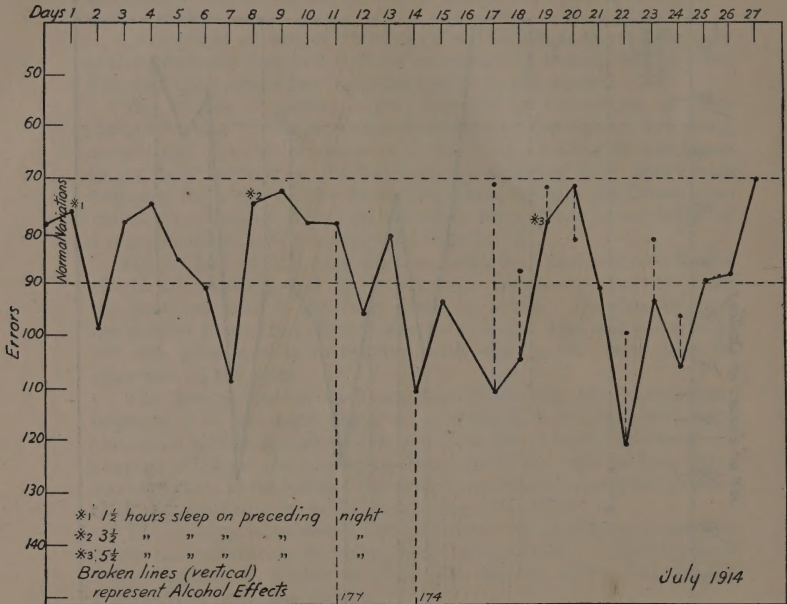
dotting before alcohol is followed by 45 after alcohol. This improvement might be interpreted as perhaps representing a certain habituation to the drug; such an hypothesis, however, is ruled out by the return two days later to a normal number of errors followed by the more frequent alcohol reaction, viz. 57 before alcohol followed by 95 after, and two days later 51 before is followed by 100 after.



GRAPH I. Showing the effects of alcohol at various stages of a 'fatigue cycle'.

This decrease in the number of errors towards the approach of the return to normality occurs in some of the 'fatigue cycles' prior to the one just described, e.g. twice in the November 1914 series, viz. on the fifteenth and nineteenth day, but as no alcohol experiments after these occur in the series, the records could not be regarded as conclusive, and in the cycle of July 1914 the same

phenomenon occurs several times from the sixteenth to the twenty-second day. This particular cycle differs somewhat from the others. The aim was to see what difference was made if, instead of cutting down sleep for three nights in succession, the same loss of sleep was spread out over a longer period, i.e. one night with only $1\frac{1}{2}$ hours' sleep was followed by a period of six days when more than the usual amount of sleep was taken; then a night with only $3\frac{1}{2}$ hours' sleep occurred, followed by ten ordinary nights, when a third night of $5\frac{1}{2}$ hours' sleep was spent. Now there are two alcohol



GRAPH II. Showing the effect of alcohol on a 'fatigue cycle' when the loss of sleep occurred at intervals, and not on successive days.

records on the eleventh and fourteenth days, each of which gives the usual increase of errors after the drug, viz. from 78 to 111 before to 177 and 174 after respectively, but on the seventeenth day 111 errors before alcohol are followed by 71 after, on the eighteenth day 105 errors are followed by 88. These records occur between the seventh and tenth day from the second night of diminished sleep; at this stage occurred the third night of shortened hours of sleep with the result that the number of errors falls from 105 on the day before to the normal 77, which is followed by 73 half an hour after taking alcohol; on the next day 71 errors before alcohol is followed by 81 after, after which for three days alcohol is followed by a slight improvement, viz. 121, 93, and 107

before alcohol are followed by 104, 82, and 91 respectively after¹ (see Graph II).

Alcohol seems thus to have a different effect according to the stage of recovery from fatigue and breaks up the curve of recovery again. It has been shown before that after considerable loss of sleep, tested by the power to give sustained voluntary attention, there is a stage when fatigue acts as a stimulant followed by a stage characterized by deterioration in the powers tested. This second phase is, according to the alcohol experiments, again divided off into two parts, (a) the stage when alcohol has the same effect as on the normal state, i.e. deteriorates the higher powers; (b) the stage when it seems to act as a stimulant and improves the work done.

It will have been noticed that in describing the effects of alcohol on the normal state a few occasions occurred when a decrease in the number of errors occurred after alcohol; in these cases the subjective statement written before doing the experiments is, with one exception, when there is no comment whatever, 'very tired', and in no case does this statement occur in the other records. Unfortunately these experiments do not determine what exactly is the degree of fatigue which can be neutralized by alcohol, for at a time when the fatigue is most acute the alcohol reaction is the more usual one.

If these results are not purely personal, then probably one reason for the very uncertain and contradictory results that investigators record with alcohol is the varying condition of the body with regard to fatigue.

Wherever regular records are available for the same person for any one test, daily fluctuations, sometimes considerable, are sure to be observed, fluctuations which, however, when they are analysed, are not as erratic as they at first appear. A long series of drug experiments is necessary before variations can without reserve be attributed to the drug. Also we might argue that the test used did not permit of much improvement, so that a drug could only affect it in one direction. Such a view must, however, consider the effect of other drugs. Some light, therefore, on the alcohol results may be thrown by the study of other drugs as, e.g. opium, and also by the combination of drugs.

(c) *The Effect of Time Intervals and Control Mixtures.*

In order to be sure that the differences apparently taking place after the drug were due to the drug and not merely to the length of time which had elapsed between the two sets of experiments, a series of experiments was made with the dotting machine test to get the effect of the time interval. These did not all take place in a daily sequence, but were interspersed among the drug experiments and extended over a period of about twelve months. There are 15 records of dotting done at intervals of 30 minutes; of these 9 show an increase of errors, 5 a decrease, and 1 no change, the average being from 78 before to 87 after. There are 25 records at intervals of one hour, of which 14 show an increase in the number of

¹ Some of the improvements are so slight that they certainly would not be considered as drug effects were it not for the fact that normally the alcohol reaction would have been to increase the errors considerably, so that a relatively slight decrease may represent a considerable effect. Cp. the effect of mixing two drugs of opposite actions, p. 27.

errors and 11 show a decrease, the average of all being an increase from 88 to 90 errors. In two of the experiments at intervals of one hour, however, there is a marked difference, viz. from 75 to 112 errors, and from 72 to 101 errors. Had a drug been taken on these days the difference would doubtless have been ascribed to it. The subjective comment for the first of these is, 'very tired'. Under ordinary circumstances the difference in dotting errors for any period between 2 o'clock and 6 o'clock is very slight; when, however, the subject was fatigued to begin with, it sometimes happened that the errors were not increased for the earlier part of the afternoon, but that the fatigue showed itself later in an increased number of errors, and invariably on the following day; and this is the interpretation of these unusual variations.

With regard to those mixtures which purported to contain drugs but which actually did not, there are 20 records, of which 9 show an increase of errors and 11 a decrease, the average being from 78 before to 79 after. Contrast these variations with those occurring after alcohol.

(d) *Opium during Normal Conditions.*

The effects of alcohol, as determined by objective tests, are thrown into relief by a consideration of the effects of opium and some other drugs here considered.

Dosage.—The doses varied from 40 minims to 90 minims of the tincture of opium, and the experimenters were the writers.

Time Interval.—It was found by experiment¹ that the maximal effect of opium was obtained between 75 minutes and 115 minutes after taking the drug. In the earlier experiments the same time interval, viz. one hour, was allowed for all drugs, but this proving too short, in the experiments here recorded a longer interval was allowed.²

There are eight experiments with doses of 40 minims, and of these all but one are followed by a noticeable decrease in the number of errors. In the case of the exception the interval was under one hour.

Details of the Experiments.

No.	Date.	Drug taken at	40 Minims.	Errors after taking the Drug.
			No. of Errors immediately before taking the Drug.	
1.	July 18, 1913	5.35 p.m.	100	72 (interval: 1 hour)
2.	July 21, 1913	5.15 p.m.	75	74 (interval too short: 40 mins.)
3.	July 24, 1913	5.10 p.m.	71	55 (interval: 1 hr.)
4.	Dec. 17, 1913	4.20 p.m.	85	43 (" 1½ hrs.)
5.	March 13, 1917	2 p.m.	62	44 (" 1 hr. 45 mins.)
6.	March 15, 1917	2.15 p.m.	82	40 (" 1 hr.)
7.	March 22, 1917	4.40 p.m.	102	68 (" 1 hr. 40 mins.)
8.	March 25, 1917	4.55 p.m.	64	42 (" 1 hr. 20 mins.)
			Mean: 80.1	Mean: 54.7

31.6 per cent. decrease in the number of errors.

¹ This was done by getting dotting records every five minutes for a period of two hours, but unfortunately circumstances did not permit the experiment at the beginning of the research.

² Although desirable in the interests of scientific research that the time intervals for all experiments should be always the same, yet in work that extends over some years, and has to be done in leisure time, it is found that the demands of practical life make such rigidity impossible.

There are 24 experiments with doses of 60 minims and in 21 cases the normal number of errors is followed by a decrease in the number of errors after opium; in the three exceptions there is a slight increase in the errors. In one case, No. 4, 90 minims had been taken on the preceding day.

60 Minims.				
No.	Date.	Drug taken at	No. of Errors immediately before taking the Drug.	Errors after taking the Drug.
1.	Feb. 18, 1914	3.7 p.m.	68	48 (interval: 40 mins.)
2.	April 5, 1914	2.45 p.m.	64	49 (" 1 hr.)
3.	May 6, 1914	2.25 p.m.	73	59 (" 1½ hrs)
4.	May 15, 1914	6.30 p.m.	84	87 (" 1 hr. 25 mins.)
5.	May 22, 1914	2.35 p.m.	89	101 (" 2 hrs.)
6.	Oct. 13, 1914	2.30 p.m.	80	61 (" 1 hr. 45 mins.)
7.	Oct. 14, 1914	3.30 p.m.	48	43 (" 2 hrs. 30 mins.)
8.	Oct. 15, 1914	2.20 p.m.	85	50 (" 2 hrs.)
9.	Oct. 17, 1914	5.20 p.m.	54	49 (" 1 hr. 35 mins.)
10.	Oct. 19, 1914	3.35 p.m.	73	48 (" 2 hrs. 15 mins.)
11.	Oct. 20, 1914	3.50 p.m.	70	64 (" 2 hrs. 15 mins.)
12.	Oct. 21, 1914	2.30 p.m.	70	61 (" 1 hr. 30 mins.)
13.	Oct. 27, 1914	3.30 p.m.	72	53 (" 2 hrs.)
14.	Oct. 29, 1914	4.5 p.m.	73	52 (" 2 hrs.)
15.	Nov. 3, 1914	3.30 p.m.	68	57 (" 2 hrs)
16.	Nov. 4, 1914	2.25 p.m.	52	35 (" 1 hr. 50 mins.)
17.	Dec. 9, 1914	3.55 p.m.	64	40 (" 1 hr. 50 mins.)
18.	Nov. 22, 1915	3.30 p.m.	84	76 (" 3 hrs.)
19.	May 18, 1916	3 p.m.	80	50 (" 2 hrs. 30 mins.)
20.	April 24, 1917	3 p.m.	76	40 (" 1 hr. 30 mins.)
21.	May 7, 1917	4 p.m.	70	82 (" 2 hrs. 30 mins.)
22.	May 12, 1917	4.55 p.m.	108	50 (" 1 hr. 30 mins.)
23.	June 21, 1919	1.40 p.m.	98	84 (" 3 hrs.)
24.	June 26, 1919	3.30 p.m.	106	62 (" 2 hrs. 30 mins.)
			Mean: 75.4	Mean: 58.4

22.5 per cent. decrease in number of errors.

There are only a few experiments with doses of 80 and 90 minims—too few to be of any statistical value.

With such doses of opium the general result is that a test which demands for its successful execution concentrated voluntary attention is in the majority of cases improved, a result in marked contrast to the effect on this test of alcohol. We cannot compare the effect of increasing the dosage as there are too few experiments with the smaller amount.

A marked subjective effect was the feeling that the machine was going less quickly, so that there seemed to be more time to 'dot' easily. The dotting was also neater.

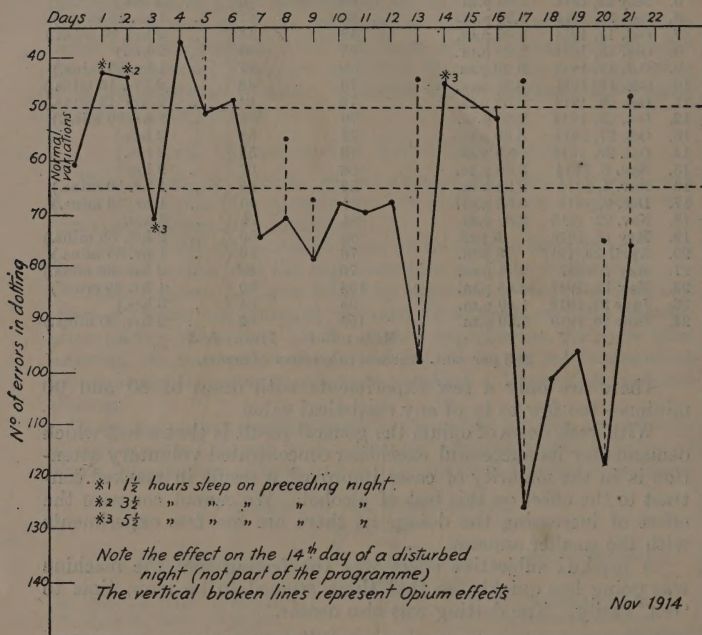
(e) *Opium during Fatigue.*

The conditions for determining the effects of opium on a fatigued state were similar to those described above for alcohol, but it was not thought desirable to include so many doses. As it gave the same results in several 'fatigue cycles', the results have been pooled, as no one fatigue cycle contains sufficient experiments.

There are sixteen records of opium effects at various stages of a fatigue cycle, viz. (a) during the actual period of shortage of sleep, (b) during the earlier stage of recovery, when, as shown in a previous article,¹ tasks involving either memory or

¹ Smith, 'A Contribution to the Study of Fatigue', *Brit. J. Psychol.*, 1916, 8, 329.

attention are considerably deteriorated, and (c) during the later stage of recovery immediately preceding the return to normal, when alcohol has the effect of improving work. Seven of these records occur during phase (a), and the effect of the opium in all cases is to improve the dotting, so that an average of 77 errors before the drug is followed by an average of 63 errors after. Nine records occur during phase (b) and (c) which, however, are not differentiated by the opium; the results are the same as in the earlier phase, but more exaggerated in proportion, as the initial records show the deteriorating effect of fatigue, i.e. an average of 110 errors before taking the drug is followed by an average of 73 errors after. See Graph III.



GRAPH III. Showing the effect of opium at various stages of a 'fatigue cycle'.

(f) The Curve of Recovery after Opium.

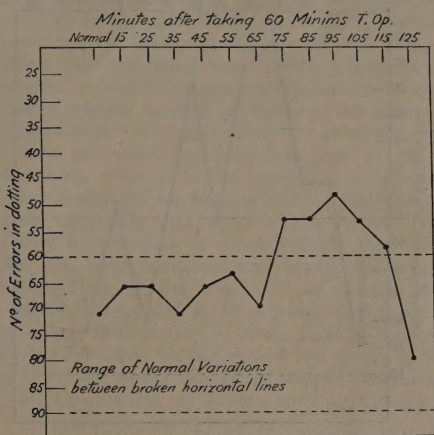
Several experiments were devoted to getting records every ten minutes, with the object of tracing the stages of the disturbance effected by opium.

The experiment that proved most suitable for such work was the dotting machine.

The procedure was to get a normal record on each occasion, then to take the drug, then to allow an interval of fifteen minutes,

after which another record was obtained, and then to obtain similar records every ten minutes. There are eight experiments and the averages of the variations for every ten minutes are given. This form of the experiment was not adopted until April 1917.

An average of 72 (extremes 60 and 90) before the drug is followed by an average of 66 fifteen minutes after, which improvement may be only a normal variation; after this normal records are obtained until 75 minutes have elapsed since the drug was taken, and the records are superior to the normal until 115 minutes have elapsed, after which there is a return to the normal. It was never possible during this series of experiments to prolong the records past this length of time, so that we have no evidence as to whether the drug has a deteriorating effect later, nor whether the normal apparently reached is reliable. Some of the experiments given above show opium effects over a longer period. See Graph IV.



GRAPH IV. Showing the effect of opium at intervals of 10 minutes.

The maximum effect of the drug as illustrated by this test is, then, between 75 and 115 minutes after taking it. Subjectively the symptoms were pronounced after about 20 minutes and frequently persisted in a vague way for several hours. Subjective variations were only noted if they were obtrusive, as it is easy to imagine symptoms if one is looking out for them.

One record traced the effect of a hypodermic injection of $\frac{1}{4}$ gr. morphine hydrochlor. In this case the effects are shown within 15 minutes, and are much more exaggerated. See Graph V.

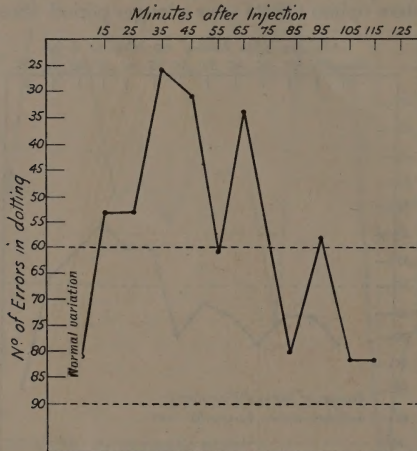
(g) Strychnine.

There are only five records of doses of strychnine varying from $\frac{1}{15}$ gr. to $\frac{3}{15}$ gr. taken by the mouth. These were done by one subject (M.S.) who was in ignorance of the drug (if any) taken. The five experiments do not occur together, but are separated by considerable intervals. The results are similar; in every case there is an

improvement after the drug, although in one case the difference is not significant. No attempt was made to get the effect of strychnine on a fatigued state, nor did we continue with this drug.

Date.	Drug taken at	No. of Errors immediately before taking Str.	No. of Errors after Str.	Dosage.	hr. min.
Feb. 12, 1914	4 p.m.	139	104	$\frac{1}{15}$ gr. St. Nit. interval	30
" 17 "	3.20 p.m.	106	94	$\frac{2}{15}$ gr. " "	1 5
" 20 "	3 p.m.	112	92	$\frac{2}{15}$ gr. " "	1 0
" 26 "	3.50 p.m.	89	84	$\frac{2}{15}$ gr. " "	1 30
Apr. 3 "	3.20 p.m.	88	79	$\frac{2}{15}$ gr. " "	1 30
		Mean: 106.8	Mean: 90.6		

15 per cent. decrease in number of errors.



GRAPH V. Showing the effect of a hypodermic injection.

III. MEMORY FOR RELATED WORDS AS A MEANS OF MEASURING THE EFFECTS OF ALCOHOL, OPIUM, AND STRYCHNINE.

This test in the form used was devised by one of us. The test required (a) that the subject should appreciate a relationship between words in sequence, and (b) be able to reproduce the words in the right sequence. A list of forty words drawn up by a collaborator was read to the subject; the list was so arranged that there was a connexion between the first word and the second, between the second and the third, and so on, a connexion which the subject could grasp by an act of attention, e.g. mountain, plain, ugly, beauty, Venus, Greece, oil, smooth, rough, refined, sugar, sweet, salt, sea, sky, angel, spirit, brandy, bottle, cork, &c.

The list was read to the subject at a uniform rate of one word in two seconds. After the list had been read through once, the

subject, having been told the first word, had to reproduce verbally the complete list in right sequence: failure to give the correct word within ten seconds counted as one error, in which case the collaborator gave the correct word and the subject proceeded; a wrong word corrected¹ by the subject within ten seconds counted as half an error.

(a) *Alcohol during Normal Conditions.*

With this test there are only three alcohol experiments under unfatigued conditions, as it did not form part of the original plan. Under normal conditions the average number of errors in a list of forty words was 7 (extremes 5 and 9); after 15 c.c. alcohol the errors rise to 20, 16, and $20\frac{1}{2}$ respectively for the three experiments.²

Analogous to the belief that the dotting was very good was the conviction (almost invariably present after the drug, which proved to be alcohol), that the particular list was very easy, and that no difficulty would be experienced in reproducing it correctly, a comfortable conviction soon shattered when put to the test.

During the period following loss of sleep, when one is trying to make up for previous strain by extra sleep, one's attention in doing this test is apt to wander, so that (a) many of the sequences are not heard with meaning, i. e. they just affect one as auditory sensations; (b) in some cases the word is heard and part of its significance grasped, but not its relation to the preceding or succeeding word, a very necessary condition for success in this particular test; it is to this failure of attention that many of the errors due to fatigue are made. Now in the case of alcohol there was no failure to attend to the list, each sequence was heard and comprehended, hence the feeling that the list was easy; at the conclusion of the reading the whole list seemed to be present to consciousness for a moment, and so one felt assured of one's perfect success in reproduction; as soon, however, as the signal was given by the collaborator saying the first word, the whole seemed dramatically to be wiped out, and the number of errors ensuing always astonished the subject.

(b) *Alcohol during Fatigue.*

The general conditions have been already described in the section devoted to the 'dotting' experiments. During several fatigue cycles this test was used with similar results, so only one is given in detail.

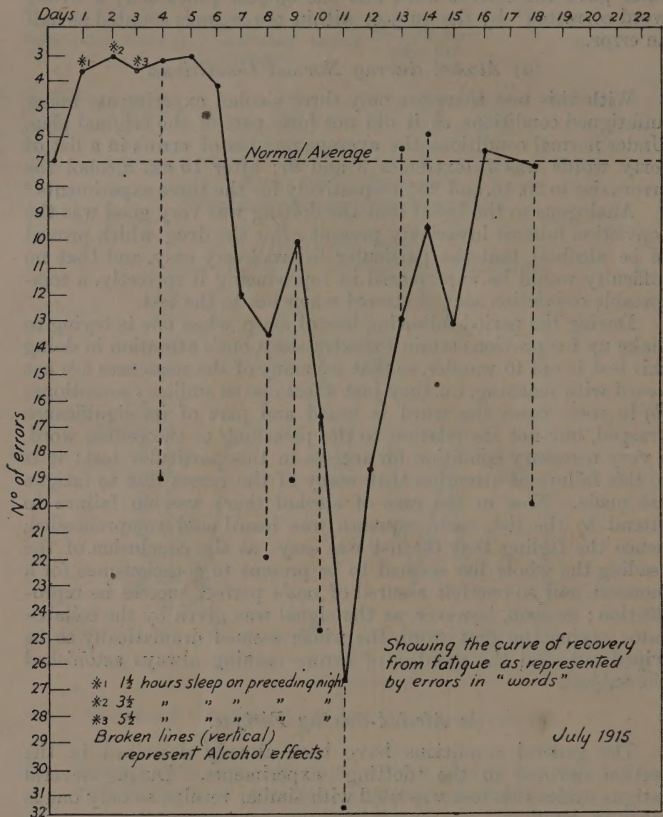
The dosage was in each case 15 c.c. and the time of day for each experiment 3 p.m.

As a result of one night of $1\frac{1}{2}$ hours' sleep the errors in words fall from an average of 7 for the preceding fortnight to $3\frac{1}{2}$; half an hour after having taken 15 c.c. alcohol the number of errors is 21. Three days later alcohol records were again obtained and the errors increase from 3 before the drug to 19 after. Four days

¹ A list unknown to the subject has of course to be used for every experiment. As lists vary in interest and difficulty the list is not quite as useful as the 'dotting', but the subjects of these experiments had had so many experiences of the test that the number of errors was found to be very regular under normal conditions.

² The dates are from May 28 to June 3, 1919, between 4 p.m. and 6 p.m.

later, by which time the second fatigue phase was in evidence, as shown by the rise in errors to $13\frac{1}{2}$, after alcohol the errors rise to 22, and for several days there are similar records (see Graph VI).



GRAPH VI. Showing the effect of alcohol at various stages of a fatigue cycle as represented by the number of errors in lists of 'words'.

On the thirteenth day, however, when the graph shows a consistent tendency to approach the normal, the alcohol reaction is different, for the errors in the words decrease after the drug from 13 to $6\frac{1}{2}$, with a similar result on the following day, viz. $9\frac{1}{2}$ errors before is followed by 6 errors after. This effect, as stated previously, cannot be interpreted as representing a certain habituation to the drug, for on the eighteenth day, when the effect of the loss of sleep had worn off, the normal number of errors of 7 is followed after alcohol by the normal alcohol reaction, viz. increase to 20.

The related words test thus gives a result similar to the 'dotting' test, viz. breaks up the second fatigue phase into two stages, (a) the stage when alcohol has the same effect as on the normal state, i.e. deteriorates the higher powers as represented by attention and memory; (b) the stage when it seems to act as a stimulant and improves the same powers.

(c) *Opium.*

As this test was added after many experiments with the dotting machine, there are fewer records and none with 40 minims. With 60 minims there are 11 records and in 10 of these there is a decrease in the number of errors, the exception being No. 2.

No.	Date.	Drug taken at	No. of Errors immediately before taking the Drug.	No. of Errors after taking the Drug.	hr. min.
1.	May 22, 1914	2.35 p.m.	7	5	(interval: 2 5)
2.	Oct. 13 "	2.30 p.m.	7	8	" " 1 50)
3.	Oct. 17 "	5.20 p.m.	5½	3	" " 1 40)
4.	Oct. 21 "	2.30 p.m.	7	3	" " 1 35)
5.	Oct. 27 "	3.30 p.m.	9½	0	" " 2 5)
6.	Oct. 29 "	4.5 p.m.	14	2	" " 2 5)
7.	Nov. 3 "	3.30 p.m.	9	4½	" " 2 5)
8.	Nov. 4 "	2.25 p.m.	7	2½	" " 1 55)
9.	Nov. 22, 1915	3.30 p.m.	7½	6½	" " 3 5)
10.	Apr. 24, 1917	3 p.m.	12	1	" " 1 35)
11.	May 7 "	4 p.m.	5	2½	" " 2 35)
			Mean: 8.2	Mean: 3.4	

58 per cent. decrease in number of errors.

In a few of the experiments the improvement is almost dramatic, the errors falling, as in No. 5, from 9 before to 0 after, a difference never occurring under normal conditions.

Another characteristic of the reproduction after opium is the speed with which the list is reproduced. The conditions of the test are, that the length of time allowed for the reproduction of the succeeding word is not to exceed ten seconds. Normally it takes 2½ minutes to reproduce the list; after opium the time taken is between 1 and 1.5 minutes, and the words seem to roll themselves off automatically, in marked contrast to the great difficulty experienced with alcohol in reproducing even those that are known. The subjective attitude, too, towards the list is different, for not only is the relationship between the successive words grasped, but when listening to the list the subject finds himself making tentative mental suggestions for the next word and noting the different relationship between the anticipated word and the actual word. Normally this rarely occurred, the two seconds allowed for the word being occupied in grasping the relationship.

Opium thus seems to improve the capacity to attend to and to reproduce sequences of related words.

(d) *Strychnine.*

There are only three experiments with this test, but the effect is the same in every case, viz. a distinct improvement. The average normal of these three cases is 5 errors; after the drug the errors are 0, 3, ½ respectively, thus giving a result akin to that of opium and opposed to the usual effect of alcohol.

IV. COMBINATION OF THE 'DOTTING' MACHINE AND MEMORY FOR RELATED WORDS AS A MEASURE OF THE EFFECTS OF ALCOHOL AND OPIUM.

This test was originally used in order to test the reliability of that improvement which shows itself in the tests done separately as a result of considerable fatigue.¹ A collaborator read a list of fifty related words to the subject, while the latter was dotting the usual length of tape under the usual conditions. Read at the rate of one word in two seconds, the fifty words read twice lasted the same length of time as the dotting. At the completion of the dotting the list of words was reproduced and the errors counted in the usual way. In this case the problem is to perform together two operations, both of which demand concentrated attention.

(a) *Alcohol.*

There are only three alcohol experiments with this test, but the same reaction takes place in all, and the difference in the number of errors before and after alcohol is well marked. On the first occasion of the combined test with alcohol² the normal records are 51 errors in dotting and $8\frac{1}{2}$ in words;³ half an hour after taking 20 c.c. alcohol the dotting errors are 164 and the errors in words 34. May 4, 1915, 3-4 p.m.

The next experiment, on May 6, results in the normals of 61 and $9\frac{1}{2}$ for dotting and words respectively, being followed by 133 and 28 after 20 c.c., while in a third experiment, May 7, 1915, 69 dotting errors and 4 errors in words are followed by 93 dotting errors and $32\frac{1}{2}$ errors in words.

Alcohol thus affects the double process test similarly to the single tests and is analogous to the operation of fatigue when the period of stimulation is over.

(b) *Opium.*

This double test had proved to be a very subtle indicator of fatigue, the two processes varying directly with one another; and with alcohol the effect was in the same direction, whether the tests were done separately or together; therefore in so far as it might be possible to form *a priori* views about the question it would be expected that the effect of opium, which is to improve each test done separately would be analogous. Instead of this, however, the effect is much more complicated. In some cases the dotting is improved and the reproduction of words is deteriorated, in others the words improve and the dotting deteriorates.

There are eight cases of the double process with a dosage of 40 minims. A slight deviation in method was made in the case

¹ *Brit. J. Psychol.*, 1916, 8, 337.

² The subject (M. S.) had had much experience of the combined test under normal and fatigue conditions before doing it with alcohol.

³ It will be noticed that the normal number of errors in dotting for the double process is fewer than when the dotting was done alone. This does not quite represent the position. The term to which this experiment belongs was one when all experiments were generally very well done; the normal average for this period for dotting done alone is 32. Sometimes for weeks together the dotting was very good; at other times for weeks it was poor.

of these experiments as only 3 metres of tape was used, and the list of words was read through once.

No.	Date.	Drug taken at	Errors immediately before taking the Drug.		Errors after taking the Drug.		hr.	min.
			Dotting and Words.	Dotting and Words.	Dotting and Words.	Dotting and Words.		
1.	Nov. 5, 1915	2.55 p.m.	33	20	43	11 (interval :	1	35)
2.	May 10 "	2.45 p.m.	26	16	20	19 ("	2	)
3.	May 23 "	4 p.m.	23	17	26	18 ("	2	30)
4.	June 7 "	2.30 p.m.	23	15	21	21 ("	1	55)
5.	June 14 "	3 p.m.	29	14	18	12 $\frac{1}{2}$ ("	2	15)
6.	March 20, 1917	4.45 p.m.	56	11	44	12 ("	1	35)
7.	March 22 "	4.40 p.m.	47	21	71	16 ("	1	55)
8.	March 25 "	4.55 p.m.	36	18	86	23 ("	1	40)

It will be noticed that in two cases, Nos. 1 and 7, the dotting is deteriorated but the words are improved; in Nos. 2, 4, and 6 the dotting is improved very slightly but the words are deteriorated; in Nos. 3 and 8 both processes are deteriorated, and in No. 5 both are improved. On May 18, 1915, the two processes were done separately to see if the subject was ceasing to be affected by the drug, with the usual result, viz. considerable improvement in both tests, 40 errors in dotting being followed by 25 after the drug, and 16 in words before followed by 6 after.

With a dosage of 60 minims there are thirteen experiments, and one of 90 minims giving similar results.

No.	Date.	Drug taken at	Errors immediately before taking the Drug.		Errors after taking the Drug.		hr.	min.
			Dotting and Words.	Dotting and Words.	Dotting and Words.	Dotting and Words.		
1.	May 11, 1915	3.5 p.m.	28	11	37	8 (interval :	3	)
2.	May 18 "	3.5 p.m.	25	16	19	11 ("	3	)
3.	June 1 "	2.30 p.m.	28	12	36	16 ("	2	)
4.	Nov. 10 "	3 p.m.	40	12	48	7 ("	2	)
5.	Nov. 11 "	3 p.m.	27	11	31	11 ("	3	)
6.	Nov. 17 "	3.35 p.m.	49	9 $\frac{1}{2}$	50	18 ("	2	)
7.	Nov. 18 "	3 p.m.	43	12	30	24 ("	2	)
8.	Nov. 29 "	3 p.m.	49	10	38	15 ("	2	)
9.	April 20, 1917	3.55 p.m.	35	4 $\frac{1}{2}$	32	5 ("	1	45)
10.	April 24 "	3 p.m.	38	12	33	1 ("	2	15)
11.	May 1 "	3.5 p.m.	58	23	57	16 ("	2	)
12.	May 5 "	4 p.m.	48	17	47	14 ("	2	)
13.	May 7 "	4 p.m.	35	5	41	2 ("	2	30)
14.	May 15 "	6.18 p.m.	45	15	126	13 ("	2	15)

(90 minims.)

It will be noticed that in Nos. 1, 4, 13, and 14 the dotting errors are increased, and the errors in words decreased; in Nos. 7, 8, and 9 the position is reversed; in Nos. 2, 10, 11, and 12 both processes are improved, but one process but slightly; in Nos. 3 and 6 both are deteriorated, while in No. 5 the dotting is slightly worse but the words unaltered. It will be noticed that in some cases the effect is very slight.

Subjectively, too, the difference before and after the drug is marked; it is, under no circumstances, easy to do the two tasks, i. e. dotting and listening to and realizing the relationship between words, together, but normally there seemed no particular tendency

to neglect one in favour of the other. After opium, however, the attention was 'always 'on the wing' in an irritating oscillation between one or other task, and it was quite possible for several sequences of words to pass by apparently unnoticed while interesting oneself in the dotting, or for a series of wild shots to be aimed at the dotting paper while attending to the words. Added to this was the dim awareness that the two tasks ought to be done together, but that this was not possible; it was as if one had work to do for which one felt quite incompetent; the total experience was thus far from pleasant. To do the two tests separately after having done them together was a delightful change. The amnesia for certain sequences of words while attending to the dotting was so great that, on being told during the reproduction what the words were, one often failed to recognize that they had ever been heard in that connexion.

Opium, as far as these experiments go, seems to have marked effects on the power of distributing attention; it improves the process of attention to an operation which can be readily dealt with as a unity by the subject, but it interferes with the power to distribute attention over more than one operation. It is perhaps this latter characteristic which is manifested in the well-known effects on people addicted to its use.

V. PERCEPTION OF AMBIGUOUS FIGURES AS AFFECTED BY ALCOHOL AND OTHER DRUGS, TEA, AND FATIGUE.

In papers published by one of us many years ago,¹ it was argued that fatigue, alcohol, chloroform, strychnine, and some other drugs produce their most distinct and immediate results upon the working of the nervous system through acting upon the synapses or junctions of neurones.

Evidence in support of this view, as regards the local fatigue immediately resulting from continued activity of a nervous path or cerebral arc, was found in the study of those phenomena of conflict and reciprocal inhibition which are familiar to workers in psychological laboratories under the names of fluctuations of the attention and binocular rivalry.

It was obvious that if these arguments were well founded, they should find further support in the study of the effects of the drugs upon these oscillatory phenomena. Of all these the alternating appearances of ambiguous figures seemed best suited for such study, and especially the 'windmill illusion'. This illusion consists in the appearance of a periodic reversal of direction of rotation when the arms of a windmill are regarded from such a position that the line of vision falls obliquely to the plane of their movement.

This illusion is a more profitable object of study than other phenomena of fluctuating perception, because it can be partially controlled by the use of binocular vision, and because the alternating phases are perfectly definite and distinct; whereas in other phenomena of this order the distinct phases are apt to be separated by

¹ McDougall, 'Physiological Factors of the Attention Process', *Mind*, 1906, N.S. 15, 340. 'Conditions of Fatigue in the Nervous System', *Brain*, 1909, 32, 256.

periods of uncertainty and confusion, e. g. ambiguous figures drawn on the flat to represent solid figures (such as the cube or the staircase figures) are apt to be seen at moments as two-dimensional only.

For the purposes of this study a laboratory windmill, the arms of which consisted of four brass rods 18 inches in length, was driven at a constant rate of three revolutions per second by a water motor. In the majority of experiments the object observed was the shadow of these rotating arms projected obliquely upon a smooth white wall by a single lamp. This arrangement has the advantage that, although the shadow windmill always appears to be rotating definitely in one or other of two planes oblique to the wall on which it is projected, there is nothing to lead the observer to regard the apparent motion in one plane as more real than that in the other, the actual windmill being hidden from his view.

It was shown in the before-mentioned studies that the observer has a certain power of favouring one or other phase of such alternating phenomena by an effort of attention, and can, therefore, by such effort either retard or accelerate the rate of alternation. For the purpose of the present study, the plan was adopted of holding fast each phase for the longest possible period; i. e. the observer set his will to hold each phase, until the change of phase occurred in spite of his effort; and then directed his effort to hold fast the new phase. Under these conditions the duration of the phases and the rate of their alternation is more regular, and after a little practice becomes very constant for each observer; though showing remarkably wide differences in different observers.¹

In one of us (McD.) the rate of alternation in his normal condition was 10–12 per minute; in the other (M. S.) it was about 6 or 7 per minute; and in a third subject it was about 2.5 per minute.²

(a) *Alcohol.*

The effect of a dose of alcohol upon this alternation of phases was in all cases a marked retardation of rate of alternation. The alcohol was taken in the form of absolute alcohol mixed with three times its bulk of water. The smallest dose was 10 c.c. of absolute alcohol. Within half an hour of its administration it had reduced the rate of alternation by nearly 50 per cent.³ No other test yet devised will in our experience reveal any effect of so small a dose of alcohol in this subject (McD.), nor was any effect subjectively appreciable. Many series of experiments were made with doses ranging from 10 c.c. to 50 c.c. absolute alcohol. It is not possible to express the results in any numerical average; but it may be said in general terms that

¹ These differences are so large and constant that they seem to be the expression of very fundamental differences of nervous constitution, and are deserving of further study.

² Although the windmill illusion is best suited for such work, observations were made also upon the alternation of phases of the ambiguous cube figure (drawn on the flat) under the various conditions described below. The rate of alternations of this figure ran closely parallel to those of the windmill under all conditions.

³ It is unfortunate that in these experiments no special attention was paid to the question of the condition of the stomach as regards food, but as they were made about noon or in the afternoon, and only a very light lunch was taken, the stomach was no doubt almost empty.

in every case the drug produced a large reduction of the rate of alternation of phases (and corresponding increase of duration of the successive phases): and that the extent of the changes were roughly proportional to the quantity of the drug taken. In many cases the observations were repeated at short intervals before and after taking the drug; and the nature of the change may best be illustrated by reporting one such series of observations which is typical of all.

January 26, 1914. Observer, McD.

2.50 p.m.	20 phases in 2 minutes
2.55 p.m.	20 " "
3 p.m.	50 c.c. Absolute Alcohol (with water) taken
3.5 p.m.	14 phases in 2 minutes
3.12 p.m.	5 phases in 2 minutes
3.17 p.m.	5 " "
3.34 p.m.	4 " "
3.45 p.m.	4 " "
4 p.m.	3 " "
4.5 p.m.	2 " "
4.17 p.m.	5 " "
4.32 p.m.	6 " "
4.42 p.m.	11 " "
5 p.m.	15 " "

From this table it appears that the effect of the alcohol gradually reached its maximum about 60 minutes after the drug passed into the stomach; after this period began to decline; and after another hour had almost passed away.

The corresponding and even more marked effect of alcohol upon the second subject (M. S.) may be illustrated by the following experiment:

The normal rate of alternation of phases is 6 or 7 per minute. She took 30 c.c. absolute alcohol. Fifteen minutes after the taking of this dose, the windmill maintained its apparent direction of rotation for 4 minutes without change; 30 minutes later it gave an initial phase lasting 35 seconds.

(b) Chloroform.

The effect of chloroform inhalation may be illustrated in a similar manner by citation of a series typical of several.

February 2, 1914. McD.

3.55 p.m.	11 phases in 60 seconds
3.57 p.m.	Four deep breaths of vapour from a piece of lint sprinkled with chloroform and held loosely over the face. This was sufficient to cause a slight giddiness, with buzzing in the ears, and a sense of swelling of the face;
immediately thereafter	2 phases in 60 seconds
4 p.m.	4 " "
4.2 p.m.	7 " "
(feeling almost normal)	
4.3 p.m.	9 " "
4.5 p.m.	10 " "
4.8 p.m.	12 " "

From this table it appears that chloroform for the dosage used in this experiment produces an effect like that of alcohol; but that,

as might be expected, the effect reaches its maximum within 1 or 2 minutes, and thereafter rapidly declines and passes away within 10 minutes.

In the second subject (M. S.), whose normal rate of alternation was 7 per minute, similar inhalation of chloroform immediately reduced the rate to five phases in 2 minutes.

In a third subject whose normal rate was 5 phases in 2 minutes, similar inhalation prolonged the first phase of the observation immediately succeeding it to 170 seconds and the second phase to 85 seconds.

(c) *Strychnine.*

The effects of strychnine on this test were studied by one observer only (McD.) who swallowed the drug on an almost empty stomach in the form of tablets of strychnine nitrate.

They may be illustrated by the following table which shows also the intercurrent effect of alcohol:

February 26, 1914.

2.15 p.m.	11 phases in 1 minute
2.20 p.m.	10 "
2.30 p.m.	$\frac{2}{15}$ gr. strychnine nitrate taken
3.15 p.m.	$\frac{1}{15}$ gr. " " "
3.40 p.m.	16 phases in 1 minute
4 p.m.	17 " "
4.15 p.m.	19 " "
4.30 p.m.	30 " "
4.35 p.m.	25 " "
4.45 p.m.	30 c.c. absolute alcohol taken in water
5.15 p.m.	7 phases in 1 minute
5.20 p.m.	8 " "
5.45 p.m.	12 " "
6.45 p.m.	15 " "
7.15 p.m.	18 " "
7.20 p.m.	18 " "

This series shows a marked effect of strychnine in accelerating the alternation of phases, an effect which reaches its maximum rather more than two hours after the passage of the drug into the stomach, and declines so slowly that three hours later it is still very marked.

The same series illustrates also the antagonism between strychnine and alcohol. The latter drug was taken at the time when the effect of the former was beginning to decline. Within half an hour it had overcome the effect of the strychnine, but was prevented by the latter from producing its full effect: half an hour later the strychnine began to predominate. After another hour the effect of the alcohol was still manifest, but after the further lapse of 45 minutes the alcohol effect seemed (in accordance with previous observations) to have passed away, leaving the declining strychnine effect to manifest itself unopposed.

A similar series of observations extending over eight hours was made on February 13, showing a similar effect of strychnine ($\frac{1}{5}$ gr.), namely, a gradually increasing acceleration of rate of alternation, reaching its maximum (33 phases per minute) about $2\frac{1}{2}$ hours after the passage of the drug into the stomach. In this case the declining curve of the strychnine effect was interrupted by the inhalation of chloroform, which immediately reduced the rate of alternation from 24 to 3 per minute.

In a third similar series $\frac{4}{15}$ gr. of strychnine nitrate produced a gradual acceleration, reaching 25 phases per minute after three hours, at which time the observations were discontinued.

From these experiments it appears that in this subject strychnine acts in a manner directly the opposite of alcohol and chloroform in respect of the 'windmill' illusion; and that its effect is counteracted by them more or less completely, according to the dosage.

(d) *Tea.*

The same subject tested the effect of tea by taking two large cups of very strong tea (the infusion of seven large teaspoonfuls). Within half an hour of the drinking of this brew, the rate of alternation rose to 27 per minute, declining to 17 per minute after a second half-hour.

(e) *Opium.*

In the same subject 80 minims of tincture of opium, taken by the mouth in a cup of weak tea at 1.30 p.m. was followed by acceleration from 10 phases per minute at 1.30 p.m. to 18 at 3 p.m., 20 at 3.10 p.m., and 22 at 3.45 p.m. On another occasion 30 minims of tincture of opium accelerated the alternation from 10 to 16 per minute after 90 minutes.

From this it appeared that opium exerts an effect the opposite of alcohol, but slower in onset and decline. These opposite effects are illustrated in the following series:

March 30. Subject, McD.

Noon	12 phases in 60 seconds.
12.15 p.m.	30 c.c. Absolute Alcohol plus 50 minims Tincture of Opium by the mouth
12.30 p.m.	9 phases in 60 seconds
12.45 p.m.	9 " "
1 p.m.	8 " "
1.15 p.m.	7 " "
2.45 p.m.	14 " "
3.15 p.m.	18 " "
3.45 p.m.	17 " "
4.30 p.m.	16 " "

This series illustrates the antagonism of opium and alcohol; before the alcohol can attain its maximum effect, it is partially counteracted by the opium, which, when after two hours the alcohol effect has declined, asserts itself in a reversal of the effect, attaining its maximum at the end of the third hour, and declining appreciably during the fourth hour.

In the other subject (M. S.) the windmill illusion was observed on five occasions after taking tincture of opium in doses varying from 40 to 90 minims. In all cases the rate of alternation of phases was markedly increased, the maximal observed rate ranging from 18 to 33 per second, according to the quantity of the drug taken.

(f) *Potassium Bromide.*

This observation is perhaps worth noting as some guarantee that the effect of drugs on the windmill illusion described above, is not due to expectation or auto-suggestion. It was anticipated

that potassium bromide would retard the alternations of phases; but no appreciable effect, either of retardation or acceleration was observed, even after as large a dose as 80 grains of potassium bromide.

(g) *Fatigue.*

In the paper referred to above¹ it was shown that when, by the use of binocular vision at close quarters, the apparent direction of movement of the windmill is maintained in one phase for an abnormally long period, this is followed by a prolonged phase of the opposite sign; that is to say, the local fatigue resulting from continued activity of a cerebral path (having its seat in all probability at the synaptic junction of the path) affects the phenomenon in the same way as alcohol and chloroform.

Miss Smith's studies of fatigue² have shown that deprivation of sleep results in a period of increased efficiency, followed by a longer period of diminished and slowly-recovering efficiency, in the concentration of attention. This initial period of increased efficiency suggests that the nervous system temporarily maintains its efficiency against oncoming exhaustion by generating some chemical substance which facilitates its operations. It is of interest, therefore, to find that, during this period of increased efficiency or facilitation of effort, the windmill illusion shows a well-marked acceleration of phases, i. e., it is affected in the same way as by strychnine, opium, and tea. This appeared clearly in two of her 'fatigue cycles' in which daily observations of the windmill illusion were made. After three nights of much shortened sleep, the rate of alternations rose from 7 a minute to 35 a minute, and only slowly returned to the normal rate in the course of a fortnight.

Summary.

The observations described above are so few and made by so small a number of subjects that they cannot be made the basis of any confident generalizations. The war has interrupted the prosecution of this method and has indefinitely postponed the prospect of their resumption by us, and we now publish them as a suggestion and clue to other workers. They suffice only to suggest that in the observation of the windmill illusion we have a very delicate method of manifesting in a quantitative manner such changes of the condition of the brain as result from fatigue and the action of drugs, such as alcohol, chloroform, strychnine, opium, and tea. They suggest that these drugs (and probably others which markedly affect the nervous system) fall into two groups of opposite effect; that those of one group (alcohol and chloroform) act chiefly and immediately by raising the resistances of the synapses in all parts of the brain, while those of the other group (strychnine, opium, and tea) produce their opposite effects by lowering the synaptic resistances; further, that the nervous system, when subjected to strain, maintains its efficiency for a time by producing a substance similar in its effects to the drugs of the second group, a substance which perhaps, like them, is of the nature of a poisonous alkaloid.

¹ *Mind*, 1901, N.S., 10.

² *Brit. J. Psychol.*, 1916, 8, part III.

These suggestions as to the nature of the effect of drugs and fatigue on the nervous system are borne out by the prolonged observations of Miss Smith of their effects upon the process of 'dotting' and of memorizing (related words test), in both of which efficiency depends upon a general concentration of attention. For the general changes in efficiency revealed by these tests under fatigue, alcohol, and opium, are all such as would seem to be satisfactorily explained by the adoption of the hypothesis suggested above.

VI. SUBJECTIVE EFFECTS OF THE DRUGS.

(a) *Alcohol.*

These subjective descriptions are all taken from the period during which the subject was in ignorance as to which drug, if any, had been taken; the statements did not all occur on any one occasion, but are extracts from many. As the general effect of a drug on consciousness is not infrequently a state for which there is no specific word, it is necessary to fall back on metaphor.

'Shortly after taking *X*, I felt very dizzy and heavy, had great difficulty in making myself begin anything, found it difficult to make an effort—feeling as if the back of my head were not there—light headed—general state akin to that in passive attention—felt as if I were a diagram, i.e. attenuated—thought the dotting was very good and words easy—tendency to perseveration, although physically disinclined to begin anything.'¹

During the period of ignorance this drug was distinguished as the 'dizzy' one, from its most obvious effect.

(b) *Opium.*

'My limbs felt as if recovering from cramp. I felt "nervy", as if about to undergo an ordeal, but without the attendant organic sensations, a feeling of excitement; I felt tired; tingling sensation, the pen felt very small so that the dotting seemed neat and dainty,² the time of the experiment seemed short; my head felt as if it were beginning to ache but in a way too undefined to be actual pain; a feeling of restless activity not unlike the first stage of excessive fatigue followed by a feeling of drowsiness combined with mental alertness; anticipatory feelings without specific object, i.e. a feeling as if something were going to happen, giving a vague fear of the unknown, sometimes pleasurable, sometimes painful, determined by factors I could not isolate.' This latter state is not exclusive to opium, most people being aware of it occasionally under apparently normal conditions, but it occurred so frequently in the records which proved to be opium days, that it seems to be a direct drug effect.

Although most tasks were improved by opium, yet the success was always somewhat tremulous, a success which appeared to be

¹ See 'Alcohol' by Members of the Advisory Committee to the Central Control Board (Liquor Traffic), ch. 3, p. 30.

² An object falling, however, so as to be seen indirectly appeared unnaturally large.

uncontrollable and therefore surprising; familiar though the subject became with these opium effects, yet surprise was always experienced at the resulting improvements. These subjective effects all became less marked in time. A feeling of drowsiness sometimes lasted several hours afterwards.

VII. SOME PRACTICAL APPLICATIONS TO THE STUDY OF ALCOHOL.

Having found that alcohol has measurable effects, and that the dotting test was a sensitive indicator of these effects, it was decided, at the suggestion of Lord d'Abernon (chairman of the Central Control Board of the Liquor Traffic), to apply this knowledge to the following problems:

(1) To find out what was the effect, if any, of the degree of the dilution of the alcohol.

(2) To compare the effects of alcohol taken immediately after a meal with its effects several hours after a meal.

(a) The Effect of the Degree of Dilution.

In this investigation only the dotting experiment was used and the tests could only be undertaken by one of us (M.S.).¹ The experiments were done after the lapse of about two years from most of the previous drug experiments. In a preliminary series of experiments with different degrees of dilution it was found that little difference was revealed between the concentrated and diluted solutions, but as these were done within an hour of a meal the reason was not far to seek, as will be seen by reference to the next section. In the final experiments undertaken some months after, an interval of at least $2\frac{1}{2}$ hours from a meal had elapsed before beginning the experiments.

Two degrees of dilution were used:—

- (1) 20 c.c. absolute alcohol diluted to 60 c.c. with water.
- (2) 20 c.c. " " 200 c.c. "

The two sets were done for the most part on alternate days but no definite rule was observed, and the experiments extended over a period of several weeks.

It had been found in previous investigations that the maximal effect of such doses of alcohol as were used in these experiments occurred about 30 minutes after taking the dose; this interval was therefore chosen on those occasions when records every few minutes could not be obtained.

The method was as follows:

After an interval of at least $2\frac{1}{2}$ hours from a meal the usual length of tape was dotted, then the solution of alcohol, diluted or concentrated, was taken, and after an interval of 30 minutes another strip of the tape was dotted.

¹ The other tests which had proved to be refined enough for the purpose, i. e. the lists of related words and the windmill, could not be used owing to war time conditions; only one of the writers was available for the experiments, and that at less certain times, and there was no laboratory accommodation such as is required to operate the windmill.

Details of the Experiments.

A. Concentrated Solution.

Date.	Interval from preceding Meal.	Errors before taking the Drug.	Errors 30 Minutes after taking the Drug.
June 2, 1919	2½ hrs.	56	170
June 10, 1919	2½ hrs.	35	73
June 12, 1919	4 hrs.	45	128
June 16, 1919	2½ hrs.	42	185
June 18, 1919	2½ hrs.	46	65
June 19, 1919	3¾ hrs.	33	101
		Mean = 43	Mean = 112

160 per cent. increase in the number of errors.

B. Diluted Solution.

June 7, 1919	3¾ hrs.	36	29
June 9, 1919	2½ hrs.	46	70
June 15, 1919	2¾ hrs.	47	64
June 20, 1919	4 hrs.	46	61
June 23, 1919	3¾ hrs.	52	61
June 24, 1919	2½ hrs.	42	46
		Mean = 45	Mean = 55

22 per cent. increase in the number of errors.

The average number of errors before taking the alcohol of the more concentrated solution was 43; for almost 25 minutes after taking the dose there are only normal variations, but 30 minutes after, the errors rise to an average of 112, an increase of about 160 per cent., after which there is a gradual return to normal. In the case of the experiments with the weaker solution the average number of errors before taking the alcohol is 45; 30 minutes after the errors rise to 55, an increase of 22 per cent. In one case with the weaker solution there is a slight improvement, and in the other cases the increase is very little greater than might have occurred as a normal variation; the concentrated solution, on the other hand, in every case gives a variation after alcohol much greater than could have been due to a normal variation.

Thus the weaker the solution, the less marked is the effect. Subjectively the same experience occurred; both the solutions were noticeable subjectively, but the concentrated one was much more so.

(b) The Effect of a preceding Meal.

Tests.—The tests used were (i) the dotting; (ii) lists of related words; (iii) a few experiments with the aesthesiometer.

Dosage.—30 c.c. absolute alcohol diluted to 60 c.c. with water.

Time of day.—This was kept constant for both sets, viz. from 5.45 p.m., except in one case, that on April 29th which was done before breakfast.

RESULTS.

(i) *The Effect on the Dotting.*

Date.	No. of Hours from a Meal.	No. of Errors immediately before taking the Drug.		Errors 30 Mins. after taking the Drug.	
		Dotting.	Words.	Dotting.	Words.
March 16, 1919	5	26		103	
March 26, 1919	2½	32	4½	92	19½
April 2, 1919	2	39	9	93	21
April 29, 1919	11	39		90	
April 30, 1919	4½	44	6	96	19
May 4, 1919	4½	50	6½	85	12
May 11, 1919	4½	36		56	
May 21, 1919	4½	34	7½	56	16
June 2, 1919	4	45	6	79	15
		Mean = 38	Mean = 6.6	Mean = 83	Mean = 17

For the nine experiments done several hours after a meal the average number of errors in dotting before taking the drug was 38. Within 30 minutes of taking the drug the errors rise to 83, an increase of 118 per cent. Subjectively, the effects of dizziness and a feeling of constriction of the muscles of the face showed themselves within 15 minutes and increased in intensity for 30 minutes.

Date.	No. of Errors before taking the Drug.		No. of Errors 30 Mins. after taking the Drug.	
	Dotting	Words.	Dotting	Words.
Feb. 18, 1919	32		39	
Feb. 21, 1919	33		39	
May 25, 1919	39		35	
June 5, 1919	40	7½	44	6½
June 9, 1919	32		28	
June 11, 1919	27	8½	29	13½
Mean = 34		Mean = 8	Mean = 36	Mean = 10

For the six experiments done immediately after a meal¹ the average number of errors before taking the drug is 34, and the average is only 36 errors 30 minutes after taking the drug, barely 6 per cent. increase; this result is in marked contrast to the previous set. Subjectively, too, the symptoms were so slight as to escape notice unless attention was given to them.

(ii) *The Effect on the Lists of Words.*²—The average number of errors before taking alcohol for those days when no meal had been taken for several hours was 7; 30 minutes after the drug the errors rose to an average of 17. For the two experiments done immediately after a meal the average number of errors was 8; 30 minutes after, 10.

(iii) *The Effect on the Aesthesiometer.*³—The distance taken as the standard was 25 cm. 4½ hours after a meal the average number of errors was 24 per cent.; after alcohol the errors rose to 90 per cent. When, however, the test was done immediately after a meal, the errors varied from 18 per cent. before to 27 per cent. after, a quite small deviation.

Summary.—Alcohol to the amount of 30 c.c. taken with a meal has very little effect as far as these tests are concerned and the

¹ For the purpose of these experiments the meal taken was a light one, usually tea, bread and butter, and an egg.

² Lists of words could not be done every time as a collaborator was needed.

³ See McDougall, *Cambridge Anthropological Expedition to Torres Straits*, vol. ii, p. 189; Burt, *Brit. J. Psychol.*, 1909, 3, 115, for details of procedure.

subjective effects are very slight. But when alcohol is taken several hours after a meal it has marked effects and shows itself subjectively within ten minutes of taking the drug and objectively involves a loss of muscular control, failure of memory, and deterioration in skin sensitivity.

VIII. GENERAL SUMMARY.

Within the limits of these studies we have shown :

(a) That there are tests (and these of the higher processes) which definitely and unambiguously enable us to study objectively the effects of drugs, and that these tests are of practical application.

(b) That the subjective effects by no means are a safe criterion of the objective result.

(c) That the drugs investigated fall into two distinct groups antagonistic to each other, viz. alcohol, chloroform, and the second phase of fatigue, as against strychnine, opium, tea, the immediate effects of fatigue, and alcohol acting during certain fatigued states.

(d) That fatigue caused by loss of sleep has an action resembling that of drugs.¹

¹ Cf. Rivers, *Influence of Alcohol, &c., on Fatigue*, p. 119.

Privy Council

MEDICAL RESEARCH COUNCIL

(Formerly Medical Research Committee, National Health Insurance).

LIST OF PUBLICATIONS

June 1921

The following publications relating to the work of the Medical Research Council can be purchased through any bookseller, or directly from H.M. Stationery Office, at the following addresses: Imperial House, Kingsway, London, W.C. 2, and 28 Abingdon Street, London, S.W. 1; 37 Peter Street, Manchester; 1 St. Andrew's Crescent, Cardiff; 23 Forth Street, Edinburgh; or from E. Ponsonby, Ltd., 116 Grafton Street, Dublin.

ANNUAL REPORTS OF THE MEDICAL RESEARCH COMMITTEE:—

- | | | | |
|--------|------------|-------------|--|
| No. 1. | 1914-1915. | [Cd. 8101.] | Price 3 <i>d.</i> , post free 4½ <i>d.</i> |
| No. 2. | 1915-1916. | [Cd. 8399.] | Price 3½ <i>d.</i> , post free 5 <i>d.</i> |
| No. 3. | 1916-1917. | [Cd. 8825.] | Price 6 <i>d.</i> , post free 7 <i>d.</i> |
| No. 4. | 1917-1918. | [Cd. 8981.] | Price 4 <i>d.</i> , post free 6 <i>d.</i> |
| No. 5. | 1918-1919. | [Cmd. 412.] | Price 6 <i>d.</i> , post free 8 <i>d.</i> |

REPORT OF THE MEDICAL RESEARCH COUNCIL FOR THE YEAR 1919-1920:—

[Cmd. 1088.] Price 9*d.*, post free 11*d.*

Special Report Series

Tuberculosis:

- No. 1. First Report of the Special Investigation Committee upon the Incidence of Phthisis in relation to Occupations.—The Boot and Shoe Trade. Price 3*d.*, post free 4*d.*
- No. 18. An Investigation into the Epidemiology of Phthisis Pulmonalis in Great Britain and Ireland. Parts I and II. Price 1*s.* 3*d.*, post free 1*s.* 5*d.*
- No. 22. An Inquiry into the Prevalence and Aetiology of Tuberculosis among Industrial Workers, with special reference to Female Munition Workers. Price 1*s.* 6*d.*, post free 1*s.* 7½*d.*
- No. 33. Pulmonary Tuberculosis: Mortality after Sanatorium Treatment. Price 2*s.*, post free 2*s.* 2½*d.*
- No. 46. An Investigation into the Epidemiology of Phthisis in Great Britain and Ireland, Part III. Price 2*s.* 6*d.*, post free 2*s.* 8*d.*

Cerebro-spinal Fever:

- No. 2. Report of the Special Advisory Committee upon Bacteriological Studies of Cerebro-spinal Fever during the Epidemic of 1915. *Out of print.*
- No. 3. Bacteriological Studies in the Pathology and Preventive Control of Cerebro-spinal Fever among the Forces during 1915 and 1916. Price 1*s.* 6*d.*, post free 1*s.* 8½*d.*
- No. 17. I. A Report upon the Seasonal Outbreak of Cerebro-spinal Fever in the Navy at Portsmouth, 1916-1917.
- II. The Treatment of Cerebro-spinal Meningitis by Antimeningococcus Serum at the Royal Naval Hospital, Haslar, 1915-16-17. Price 2*s.* 6*d.*, post free 2*s.* 9*d.*
- No. 50. Cerebro-spinal Fever. Studies in the Bacteriology, Preventive Control, and Specific Treatment of Cerebro-spinal Fever among the Military Forces, 1915-19. Price 4*s.*, post free 4*s.* 3½*d.*

Special Report Series—continued.

Dysentery :

Reports upon Investigations in the United Kingdom of Dysentery Cases received from the Eastern Mediterranean.

No. 4. I. Amoebic Dysentery and the Protozoological Investigation of Cases and Carriers. Price 1s., post free 1s. 2d.

No. 5. II. Report upon 878 Cases of Bacillary Enteritis. Price 4s. 6d., post free 4s. 8d.

No. 6. III. Report upon recovered Cases of Intestinal Disease in the Royal Naval Hospital, Haslar, 1915-16.

IV. Report upon combined Clinical and Bacteriological Studies of Dysentery Cases from the Mediterranean. Price 4s. 6d., post free 4s. 8d.

No. 7. V. Report upon 2,360 Enteritis 'Convalescents' received at Liverpool from various Expeditionary Forces. Price 6s., post free 6s. 2½d.

No. 15. A Study of 1,300 Convalescent Cases of Dysentery from Home Hospitals: with special reference to the Incidence and Treatment of Amoebic Dysentery Carriers. Price 1s. 3d., post free 1s. 4d.

No. 29. A Contribution to the Study of Chronicity in Dysentery Carriers. Price 9d., post free 10½d.

No. 30. An Investigation of the Flexner-Y Group of Dysentery Bacilli. Price 1s., post free 1s. 1½d.

No. 40. Studies of Bacillary Dysentery occurring in the British Forces in Macedonia. Price 3s., post free 3s. 2d.

No. 42. A Study of the Serological Races of the Flexner Group of Dysentery Bacilli. Price 2s., post free 2s. 2d.

Venereal Diseases :

No. 23. An Analysis of the Results of Wassermann Reactions in 1,435 Cases of Syphilis or Suspected Syphilis. Price 2s., post free 2s. 1½d.

No. 41. I. An Investigation into the Ultimate Results of the Treatment of Syphilis with Arsenical Compounds.

II. A Clinical Study of the Toxic Reactions which follow the Intravenous Administration of '914'. Price 2s., post free 2s. 1½d.

No. 44. Reports of the Special Committee upon the Manufacture, Biological Testing, and Clinical Administration of Salvarsan and of its Substitutes. No. 1. Price 1s., post free 1s. 1½d.

No. 45. Undisputed Involvement of the Central Nervous System in Syphilis. Price 1s., post free 1s. 1½d.

No. 47. The Accuracy of Wassermann Tests, applied before and after death, estimated by Necropsies. I. The Wassermann Test applied before death. Price 2s. 6d., post free 2s. 8d.

No. 55. I. Results of the Examination of Tissues from Eight Cases of Death following Injections of Salvarsan.

II. The Influence of Salvarsan Treatment on the Development and Persistence of Immunity, as indicated by Measurements of Agglutinins. Price 3s., post free 3s. 2d.

(Vide infra, *Reports of the Committee upon Pathological Methods*, Nos. I-IV.)

Alcohol :

No. 31. Alcohol—Its Absorption into and Disappearance from the Blood under different conditions. Price 1s., post free 1s. 1½d.

No. 34. The Influence of Alcohol on Manual Work and Neuro-muscular Co-ordination. Price 2s., post free 2s. 1½d.

No. 56. The Effects of Alcohol and some other Drugs during Normal and Fatigued Conditions. Price 1s., post free 1s. 1½d.

Reports of the Committee upon Pathological Methods :

No. 14. I. The Wassermann Test. Price 3d., post free 4½d.

No. 19. II. The Laboratory Diagnosis of Gonococcal Infections.

III. Methods for the Detection of Spirochaetes. Price 1s., post free 1s. 1½d.

No. 21. IV. The Diagnostic Value of the Wassermann Test. Price 1s., post free 1s. 1½d.

No. 35. V. The Reaction of Media. Price 6d., post free 7½d.

No. 51. VI. The Laboratory Diagnosis of Acute Intestinal Infections, including the Principles and Practice of the Agglutination Tests. Price 4s. 6d., post free 4s. 8½d.

Reports of the Special Investigation Committee on Surgical Shock and Allied Conditions :

No. 25. I-VII. Wound-Shock and Haemorrhage. Price 4s., post free 4s. 6d.

No. 26. VIII. Traumatic Toxaemia as a Factor in Shock. Price 1s., post free 1s. 1½d.

No. 27. IX. Blood Volume Changes in Wound-Shock and Primary Haemorrhage. Price 9d., post free 10½d.

Special Report Series—continued.

Reports of the Air Medical Investigation Committee :

- No. 37. VIII. The Effects of Diminished Tension of Oxygen, with especial reference to the Activity of the Adrenal Glands.
IX. The Ear in relation to certain Disabilities in Flying. Price 1s., post free 1s. 1½d.
No. 53. The Medical Problems of Flying (including Reports Nos. I-VII). Price 6s., post free 6s. 4½d.

Reports of the Committee upon Accessory Food Factors (Vitamines):

- No. 38. Report on the Present State of Knowledge concerning Accessory Food Factors (Vitamines). Price 4s., post free 4s. 3d.

Reports of the Committee upon Anaerobic Bacteria and Infections:

- No. 39. Report on the Anaerobic Infections of Wounds and the Bacteriological and Serological Problems arising therefrom. Price 6s., post free 6s. 4d.

Reports of the Committee upon Injuries of the Nervous System :

- No. 54. I. The Diagnosis and Treatment of Peripheral Nerve Injuries. Price 2s., post free 2s. 2d.

No. 8. Report upon Soldiers returned as Cases of 'Disordered Action of the Heart' (D.A.H.), or 'Valvular Disease of the Heart' (V.D.H.). Price 1s., post free 1s. 1½d.

No. 9. A Report upon the use of Atropine as a Diagnostic Agent in Typhoid Infections. Price 1s., post free 1s. 1½d.

No. 10. The Mortalities of Birth, Infancy, and Childhood. Price 1s. 6d., post free 1s. 8d.

No. 11. The Causation and Prevention of Tri-nitro-toluene (T.N.T.) Poisoning. Price 1s., post free 1s. 2d.

No. 12. The Classification and Study of the Anaerobic Bacteria of War Wounds. Price 2s., post free 2s. 2½d.

No. 13. An Enquiry into the Composition of Dietsaries, with special reference to the Dietsaries of Munition Workers. Price 9d., post free 10½d.

No. 16. A Report on the Causes of Wastage of Labour in Munition Factories. Price 1s. 6d., post free 1s. 7½d.

No. 20. A Study of Social and Economic Factors in the Causation of Rickets, with an Introductory Historical Survey. Price 2s., post free 2s. 2d.

No. 24. A Report on the Investigation of an Epidemic caused by *Bacillus aertrycke*. Price 9d., post free 10½d.

No. 32. The Science of Ventilation and Open Air Treatment. Part I. Price 10s., post free 10s. 6d.

No. 36. Studies of Influenza in the Hospitals of the British Armies in France, 1918. Price 3s. 6d., post free 3s. 8½d.

. 43. Albuminuria and War Nephritis among British Troops in France. Price 2s. 6d., post free 2s. 8½d.

No. 48. A Report on the probable Proportion of Enteric Infections among Undiagnosed Febrile Cases invalided from the Western Front since October, 1916. Price 3s., post free 3s. 2d.

No. 49. On the Destruction of Bacteria in Milk by Electricity. Price 9d., post free 10½d.

No. 52. The Science of Ventilation and Open Air Treatment. Part II. Price 6s., post free 6s. 5d.

No. 57. Studies in Wound Infections. Price 4s. 6d., post free 4s. 9d.

No. 58. T.N.T. Poisoning and the Fate of T.N.T. in the Animal Body. Price 3s., post free 3s. 2d.

No. 59. A report on the Occurrence of Intestinal Protozoa in the Inhabitants of Britain. Price 2s., post free 2s. 2d.

The following were published under the direction of the Medical Research Committee :

Milk and its Hygienic Relations, by Janet E. Lane-Claypon, M.D., D.Sc. (Lond.). Price 9s.net. [Longmans, Green & Co.]

The Amoebae living in Man, by Clifford Dobell, F.R.S. Price 7s. 6d. net. [Bale, Sons & Danielsson, Ltd.]

In addition to the publications contained in the list given above, numerous memoirs upon work aided by the Medical Research Council have appeared in Scientific Journals.

MEDICAL SCIENCE

Abstracts & Reviews

PUBLISHED MONTHLY FOR THE MEDICAL
RESEARCH COUNCIL

BY

HUMPHREY MILFORD

OXFORD UNIVERSITY PRESS

LONDON EDINBURGH GLASGOW NEW YORK

TORONTO MELBOURNE CAPE TOWN BOMBAY

THE MEDICAL RESEARCH COUNCIL aim in this
Journal at providing a summary of recent progress in the
sciences of Medicine as recorded in books or periodicals published
in all countries. Two volumes are issued annually, each provided
with a full index.

